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The impact of psychological factors on farmers' intentions to reuse agricultural biomass waste for carbon emission abatement

Linli Jiang [a, b, c], Junbiao Zhang [a, c, *], H. Holly Wang [d, b], Lu Zhang [a, c, **], Ke He [a, c]

[a] College of Economics & Management, Huazhong Agricultural University, Wuhan, 430070, China
[b] Department of Agricultural Economics, Purdue University, West Lafayette, 47907, USA
[c] Hubei Rural Development Research Center, Wuhan, 430070, China
[d] Institute of Agricultural Resources and Regional Plan, Chinese Academy of Agricultural Sciences, Beijing, 100013, China

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A B S T R A C T

Existing studies on farmers' willingness to reuse agricultural biomass waste usually focus on individual and social economic characteristics without consideration of the underlying psychological factors. This paper uses the theory of planned behavior, a typical social psychology model, to identify the psychological constructs that affect farmers' intentions to reuse agricultural biomass waste for carbon emission abatement. According to this theory, an individual's behavior is driven by the individual's intention, which in turn is determined by the individual's attitude, subjective norm and perceived behavioral control. Structural equation modeling was used to analyze the logical relationships among these constructs. The results showed that farmers' intentions were significantly determined by their attitudes, followed by their perceived behavioral controls. Meanwhile, multiple-group analyses were conducted to determine the differences of the driving factors between different types of farmers on their intentions to reuse agricultural biomass waste. Subjective norms were proven to be a factor affecting the reuse intentions of the farmers who are female, highly educated, having high income or less farming experience. These findings can be used by policy-makers to formulate incentive policies to motivate farmers' agricultural biomass waste reuse intentions or even behaviors. Effective approaches should be developed to cultivate farmers' positive attitudes, ecological benefits awareness and social norms consciousness, in order to arouse their enthusiasm for participating in reuse practice to mitigate climate change. The conclusions of this study also provide an important scientific basis for developing countries and regions to encourage farmers to reuse agricultural biomass waste for carbon emission abatement.

1. Introduction

One of the largest threats facing the world today is the increasing severity of climate change associated with greenhouse gas (GHG) emissions (Saunders et al., 2006; Liu et al., 2012; Quiggin, 2013). Compared to pre-industrial levels, the concentrations of major greenhouse gases in the atmosphere including CO_2, CH_4, and N_2O caused by human activities have increased by 40%, 151% and 20% in 2012, respectively (U.S. EPA, 2014). According to the data published by the Intergovernmental Panel on Climate Change, agricultural carbon emissions contribute to almost 30% of all human activities' carbon emissions (IPCC, 2014). In particular, the burning of agricultural waste has been proven to be a non-negligible source of CO_2 emissions leading to global warming (Yan et al., 2015; Sun et al., 2016), which has also seriously hindered the environmental governance and sustainable development in rural areas (Cheng et al., 2011). However, agricultural waste can be valued as a biomass resource (Matsumura et al., 2005) that can provide an income stream from carbon abatement for farmers (Sohi, 2012). It also has the potential to be an alternative of fossil fuel to mitigate climate change worldwide (Navia and Crowley, 2010; Liu et al., 2012).

As a vast agricultural country, from both domestic and international perspectives, China needs to transform its agricultural development pattern from the traditional extensive mode to a low

* Corresponding author. College of Economics & Management, Huazhong Agricultural University, Wuhan, 430070, China.
** Corresponding author. College of Economics & Management, Huazhong Agricultural University, Wuhan, 430070, China.
E-mail addresses: jianglinli1225@hotmail.com (L. Jiang), zhangjunbiao@mail.hzau.edu.cn (J. Zhang), luzhang@mail.hzau.edu.cn (L. Zhang).

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carbon economic one to achieve a win-win situation between the environment and development (Zhang, 2010; Bing et al., 2010). In recent years, reusing agricultural biomass waste[1] has drawn the attention of the Chinese government. The Chinese government (2013) stressed the significance of reusing agricultural crop straws and the urgency of prohibiting the common practice of open burning to reduce air pollution and global warming. Additionally, national development planning was also established in China (2015) to strongly promote the national comprehensive utilization of agricultural biomass waste, with a target of zero emission by 2030. Although different utilization measures are currently available to farmers, their adoption intentions remain low. Hence, as farmers are the real implementers and stakeholders, a better understanding of their motives to reuse agricultural biomass waste could help policy-makers design extended policies and carbon emission abatement (CEA) programs to enhance agricultural sustainability (He et al., 2016a).

In previous studies, the utilization measures of agricultural waste have been developed (Mohan and Singh, 2002; Guo et al., 2010), and the CEA potential of such measures has also been evaluated (Weitz et al., 2002; Navia and Crowley, 2010; Liu et al., 2012). Most of the existing studies on farmers' reuse decisions with regard to agricultural waste have paid a great deal of attention to the impact of various socioeconomic factors, such as farmers' educational levels and agricultural incomes (Shehrawat et al., 2015; Jiang et al., 2014). Nevertheless, these socioeconomic characteristics have not been able to fully explain the real motives of farmers' decisions and behaviors (Knowler and Bradshaw, 2007; Hansson et al., 2012). Borges and Lansink (2016) argue that the existing literature is inconclusive about the determinants of farmers' behaviors, possibly due to the ignoring of the role of psychological factors.

Among all of the socio-psychological methods, the theory of planned behavior (TPB) is most widely used to identify the psychological factors that influence people's intentions and behaviors. The TPB is developed by Ajzen (1991) on the basis of the theory of reasoned action. It asserts that an individual's decisions do not depend entirely on one's subjective wishes, but they are mainly restricted by certain objective factors such as knowledge, resources and opportunities. According to the TPB, three socio-psychological constructs, including attitude (positive or negative evaluations with regard to performing a specific behavior), subjective norm (social pressures on performing a specific behavior) and perceived behavioral control (perceptions about one's own capabilities to perform a specific behavior based on his or her experience and resources), together determine one's intention (willingness to perform a specific behavior), and then intention is the key factor and motivation that determines actual behavior. Meanwhile, perceived behavioral control can directly predict actual behavior (Ajzen, 1991). The TPB has been employed in studying low carbon tourism (Bamberg and Schmidt, 2003), household recycling (Kaiser and Gutscher, 2003), organic food consumption (Zhang et al., 2013; Yazdanpanah and Forouzani, 2015), and other environmental issues. In the context of agriculture, the TPB has also been used to analyze farmers' conservation behaviors (Beedell and Rehman, 2000), climate change adaptation intentions (Truelove et al., 2015), and innovative technology adoption decisions (Borges and Lansink, 2016). The TPB provides a significant theoretical foundation for predicting farmers' intensions and behaviors (Chin et al., 2016), thus it can offer great insights into the psychological factors that drive farmers' intentions to reuse agricultural biomass waste.

In the light of the foregoing, this paper, from the socio-psychological perspective, attempts to identify the impact of farmers' cognitions[2] including the three components of attitudes, subjective norms and perceived behavioral controls on their intentions to reuse agricultural biomass waste. To determine the relative importance of these three constructs, structural equation modeling was used to simultaneously estimate all of the relationships in the TPB model. Furthermore, multiple-group analyses were conducted to study the differences of the driving factors between different types of farmers in their intentions to reuse agricultural biomass waste. The results drawn from this study will help policy-makers to adjust existing policies and design CEA programs that offer incentives for the reuse of agricultural biomass waste.

2. Research methods and data

2.1. The theory of planned behavior

In the TPB model, three socio-psychological constructs including attitude, subjective norm and perceived behavioral control together determine intention, which will further determine actual behavior. In general, when people hold positive evaluations of a specific behavior, feel higher social pressures to perform the behavior, and think they have more resources, opportunities and fewer perceived hindrances, their intentions to act will be stronger. In the context of this paper, farmers' intentions to reuse agricultural biomass waste (RABW) will be higher when they hold a positive evaluation towards RABW and realize that RABW is the advocated behavior of society, and they will perceive the feasibility of RABW in their own capabilities, such as labor, capital and technology, and then adopt actual actions.

According to Wauters et al. (2010), attitude is defined as farmers' positive or negative evaluations of a behavior. This study posits that farmers will have a higher intention to reuse agricultural biomass waste when they evaluate the practice as being mutually favorable for themselves and the environment. Subjective norm refers to farmers' perceived social pressures to reuse agricultural biomass waste, especially those that are based on the opinions of influential people around them. When farmers perceive that RABW has been supported by important people or opinion leaders, such as village administrators, highly educated neighbors and wealthy farmers (Power et al., 1988; Yang, 2000; Sun, 2009; Gao and Bi, 2009), they will be more likely to adopt it, hoping that their actions will win social approval. Perceived behavioral control is defined as farmers' perceptions of difficulties and possibilities in RABW based on their own capabilities, including labor, capital and technology. To a certain degree, perceived behavioral control will promote or hinder farmers' intentions to act (Borges and Lansink, 2016). The more positive their perceptions are, the more feasible it will be for them to implement RABW. We propose three hypotheses to verify the applicability of the TPB model in this context, which are as follows:

Hypothesis 1. Farmers' attitudes have a positive effect on their intentions to reuse agricultural biomass waste.

Hypothesis 2. Farmers' subjective norms have a positive effect on their intentions to reuse agricultural biomass waste.

[1] Reusing agricultural biomass waste includes the following utilization measures: adding crop residues back to arable soil as organic fertilizer, producing biogas energy, making straw fodder and other measures to convert agricultural residues into bioenergy.

[2] Farmers' cognitions are defined as information processing in farmers' minds or brains when they make the decision of whether to reuse agricultural biomass waste, which is related to their own knowledge, attention, judgment and evaluation (Blomberg, 2011).

Hypothesis 3. Farmers' perceived behavioral controls have a positive effect on their intentions to reuse agricultural biomass waste.

2.2. Structural equation modeling and multiple-group analysis

Based on the TPB, this study set farmers' intentions as a dependent variable, while their attitudes, subjective norms and perceived behavioral controls were set as independent variables. Considering the difficulties in measuring unobserved latent constructs as well as subjective measurement errors, structural equation modeling (SEM) was used to analyze the logical relationships between these constructs, which could address the above shortcomings and allow for the simultaneous estimation of the relative importance of farmers' attitudes, subjective norms and perceived behavioral controls in the TPB model (Bleakley and Hennessy, 2012).

SEM is divided into measurement equation and structural equation (Jöreskog, 1967). The measurement equation is constructed to test the relationships between latent variables and their corresponding observed variables, including the exogenous latent variable equation (1) and the endogenous latent variable equation (2). The structural equation is employed to test the causal relationships between the exogenous latent variables and the endogenous latent variables, which is also known as path analysis, in equation (3).

$$X = \Lambda_x \xi + \delta \quad (1)$$

$$Y = \Lambda_y \eta + \varepsilon \quad (2)$$

$$\eta = B\eta + \Gamma\xi + \zeta \quad (3)$$

where X represents the exogenous latent variable vector, which reflects the indices of farmers' attitudes, subjective norms, and perceived behavioral controls towards RABW; ξ represents the exogenous observed variables, referring to their attitudes, subjective norms, and perceived behavioral controls; Y represents the endogenous latent variable vector, which reflects the indices of farmers' intentions in RABW; η represents the endogenous observed variable, referring to their intentions; Λ_x and Λ_y represent the correlation coefficient matrices between the exogenous latent variables, the endogenous latent variables and their corresponding observed variables, respectively; δ and ε represent the measuring error vectors of the exogenous observed variables and the endogenous observed variables, respectively; B represents the coefficient matrix between some endogenous latent variables and other endogenous latent variables, reflecting the mutual influences among the endogenous latent variables; Γ represents the structural coefficient matrix between the endogenous and the exogenous latent variables, reflecting the path coefficients of the exogenous latent variable X on the endogenous latent variable Y; ζ represents the random error term of the structural equation.

Multiple-group analysis is an important tool for verifying whether the same theoretical model can be applied to pre-defined groups by performing separate analyses on each group and estimating group-specific parameters (Marcoulides and Heck, 1993; Schumacker and Marcoulides, 1998). It is normally used to fit a consistent model simultaneously to two sets of data representing two groups (e.g. male and female), which makes the estimation results comparable. Thus, the impacts of categorical variables can be measured by comparing the coefficient estimates between different groups (Hair et al., 2014). In this study, we used the "Multiple-Group Analysis" module in AMOS software to identify the influences of six control variables (i.e., gender, age, educational level, farming experience, part-time job and income level) on farmers' reuse intentions.

2.3. Sampling and survey

The data of this study were obtained by a face-to-face questionnaire survey in six counties in the Wuhan and Suizhou regions in Hubei province, China (in Fig. 1), namely, Xinchong, Zhucheng, Chengguan, Lishan, Wandian and Sanligang, from August to September 2012. Three or four villages were randomly selected in each county, and respondents from 15 to 25 households per village were randomly selected from the list provided by the village committee.

A pilot survey was carried out with 35 farmers and 15 village administrators to ensure the questions in the questionnaire could be understood well in face-to-face conversation, and the actual survey was then administered by graduate enumerators from Huazhong Agricultural University. The final version of the questionnaire consisted of five parts: 1) the farmers' demographic and socioeconomic information; 2) the farmers' awareness of agricultural biomass waste; 3) the farmers' utilization methods of agricultural biomass waste; 4) the technical and informational requirements in reusing agricultural biomass waste; 5) the farmers' responses to the related questions based on the TPB. Finally, after more than 20 villages and 400 rural households were surveyed, a sample of 398 was obtained after eliminating questionnaires with incomplete or inconsistent key information.

2.4. The demographic and socioeconomic characteristics of the sample

The data distribution of the farmers' demographic and socioeconomic characteristics is shown in Table 1. The gender proportion of the farmers in the sample was relatively balanced, with 216 men (54.3%) and 182 women (45.7%). A significant portion of respondents (32.2%) were the middle-aged, ranging from 41 to 50. The educational level of the farmers was generally low, as follows: 11.1 percent had no formal schooling, 24.4 percent had attended primary school, 48.2 percent had attended junior high school, 14.8 percent had attended high or vocational school, and only 1.5 percent had attended college or above. More than half of the respondents (59.8%) were engaged in a second economic activity in addition to farming. The farming experience of most respondents (75.9%) reached more than 20 years. The largest group of respondents (40.95%) claimed that their family income was less than 20 thousand yuan (equals $3021) a year. Compared with the census data provided by the China rural statistical yearbook (2012) and the Hubei statistical yearbook (2013), the demographic and socioeconomic characteristics of the sampled farmers agree fairly well with

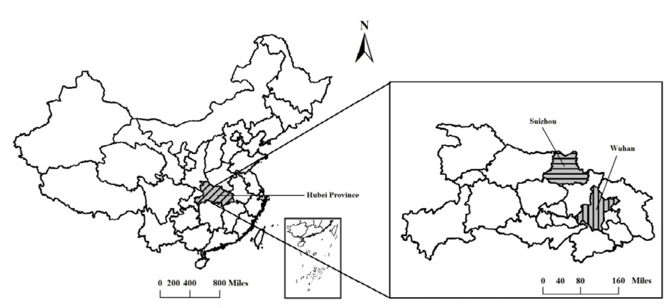

Fig. 1. Areas surveyed.

Table 1
The demographic and socioeconomic characteristics of the farmers in the sample.

Index	Item	Sample size	Percentage (%)	Index	Item	Sample size	Percentage (%)
Gender	Male	216	54.3	Part-time job	Yes	238	59.8
	Female	182	45.7		No	160	40.2
Age	≤30	16	4.0	Farming experience	≤10	23	5.8
	31–40	47	11.8		11–20	73	18.3
	41–50	128	32.2		21–30	123	30.9
	51–60	123	30.9		31–40	92	23.1
	≥61	84	21.1		≥41	87	21.9
Educational level	Illiterate	44	11.1	Income level (thousand yuan)	≤20	163	41.0
	Primary	97	24.4		21–40	90	22.6
	Junior high	192	48.2		41–60	66	16.6
	High/vocational	59	14.8		61–80	39	9.8
	College/above	6	1.5		≥81	40	10.0

Table 2
The statements and descriptive statistics of the measured items, representing attitude, subjective norm, perceived behavioral control and intention.

Construct	Item	Statement	Mean	Standard deviation
Attitude (AT) (Fielding et al., 2008)	AT1	RABW can increase my economic income.	3.75	0.892
	AT2	RABW will alleviate air pollution in rural area.	4.22	0.789
	AT3	I support the behaviors of RABW that contributes to human health.	4.27	0.772
	AT4	The utilization technologies of agricultural biomass waste are environmentally friendly.	4.25	0.785
	AT5	RABW is necessary to make our agriculture sustainable.	3.90	0.902
Subjective Norm (SN) (Fielding et al., 2008)	SN1	Village cadres think that I should participate in RABW.	3.68	1.017
	SN2	Highly educated neighbors' opinion has great influence on my decision about RABW.	3.58	0.980
	SN3	Wealthy and influential farmers would approve the behaviors of RABW.	3.42	0.980
Perceived Behavioral Control (PBC) (Oliver and Rosen, 2010)	PBC1	I have enough money to adopt the technologies of RABW.	3.28	1.118
	PBC2	I can easily get the technical support in RABW from the agricultural technical experts if I want.	3.07	1.319
	PBC3	I am confident that I can quickly learn and master the technologies of RABW.	3.25	1.176
Intention (IN) (Folse et al., 2010)	IN1	I intend to learn utilization technologies of agricultural biomass waste.	3.65	1.065
	IN2	I am willing to reuse agricultural biomass waste to protect the environment and to be in harmony with nature.	4.30	0.781
	IN3	I would like to reuse agricultural biomass waste to conform to the future development trend of low carbon agriculture.	3.55	1.058

the actual information of rural residents in Hubei province. Thus, this is a typical and representative sample for the focus of this study.

3. Results

3.1. Item measurements

A five-point Likert scale was used to evaluate each question in the final part of our questionnaire, and the five answers were "1 = strongly disagree; 2 = disagree; 3 = neutrality; 4 = agree; 5 = strongly agree." Based on several relevant studies (Fielding et al., 2008; Oliver and Rosen, 2010; Folse et al., 2010), we designed five questions to measure the five observed variables of attitudes, and three each for subjective norms, perceived behavioral controls and intentions of RABW. The specific statements and descriptive statistics of the measured items are shown in Table 2.

In general, the farmers demonstrated a strong positive attitude towards reusing agricultural biomass waste. The lowest mean for the five items used to measure attitudes was 3.75, with all the remaining attitudes items having a mean of 4.16. The farmers also indicated moderately high subjective norms and a slightly high level of perceived behavioral controls over reusing agricultural biomass waste. The mean of all items measuring subjective norms and perceived behavioral controls varied from 3.07 to 3.68. Additionally, the farmers showed a positive intention to reuse agricultural biomass waste, and the three items used to measure intentions all had a mean of at least 3.55.

3.2. Reliability and validity test

The reliability and validity of the formal survey data should be tested at the first step. The SPSS 19.0 was used to test the reliability of these four constructs. The results showed that the Cronbach's α values[3] for the farmers' attitudes and subjective norms were 0.785 and 0.744, respectively, and the Cronbach's α values for their perceived behavioral controls and intentions were 0.607 and 0.667, respectively, all of which revealed a good internal consistency. The results of the factor analysis suitability test showed that the Kaiser-Meyer-Olkin (KMO) value was 0.841, and the Bartlett's test statistic value of sphericity[4] was 1574.131 ($p = 0.000 < 0.001$), indicating that the measured items had a high correlation and were suitable for the confirmatory factor analysis (CFA).

AMOS 22.0 was used to conduct the CFA. The model results showed the following: all standardized factor loadings were larger than 0.5 and significant at the 5% critical level, indicating a good discriminant validity. Meanwhile, the parameter estimations between measured items and matching latent constructs were significant at the 1% statistical level, showing that each measured item had a strong ability to explain its corresponding latent construct.

[3] The Cronbach's α value is used to evaluate the reliability of the data. A good reliability is indicated when the Cronbach's α value is between 0.60 and 0.70; a very good reliability is when the Cronbach's α value is between 0.70 and 0.80 (DeVellis, 1991).

[4] Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity are used to measure the sampling adequacy, factorability and suitability. A KMO value of less than 0.6 indicates that the sampling is not adequate.

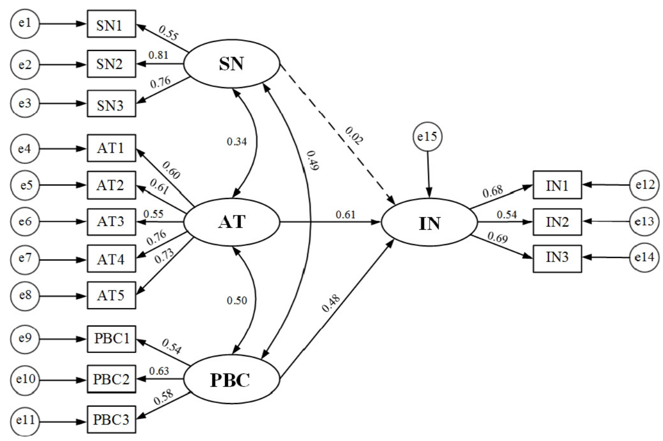

Fig. 2. Standardized factor loadings and path coefficients of the final structural model based on the TPB. Circles represent error terms, squares represent measured items, ellipses represent latent constructs, straight arrows represent dependence relations and curved arrows represent correlational relations. Solid arrows indicate significant effect while the dotted arrow indicates insignificant effect.

The goodness-of-fit indices[5] of the CFA model were as follows: chi-square value χ^2 was 79.508 ($p = 0.056 > 0.05$), $df = 61$, $\chi^2/df = 1.303$, GFI = 0.973, CFI = 0.989, NFI = 0.954, PNFI = 0.640, PCFI = 0.663, RMSEA = 0.028. These results indicated that our theoretical model fit the practical data with good validity.

3.3. Structural equation modeling and hypothesis test

According to the TPB model, structural equation modeling was used to examine the logical relationships between the farmers' cognitions (attitudes, subjective norms and perceived behavioral controls) and their intentions to reuse agricultural biomass waste. In this model, a set of multiple regressions was estimated with an emphasis on the causal relationships among the latent constructs. All of the standardized coefficients estimated from these regressions using equation (1) through (3) are labeled in Fig. 2. After reasonable revision of the original model based on the modification indices, the goodness-of-fit indices of the final model were as follows: chi-square value χ^2 was 80.692 ($p = 0.056 > 0.05$), $\chi^2/df = 1.301$, GFI = 0.972, CFI = 0.989, NFI = 0.953, PNFI = 0.650, PCFI = 0.674, RMSEA = 0.028, and other goodness-of-fit indices all achieved evaluation standards. These results suggested that the TPB model fit the practical data well, with a good construct and convergent validity, and the research hypotheses could be tested in this TPB model.

The estimation results are presented in Table 3. The standardized path coefficients of the farmers' attitudes and perceived behavioral controls on their intentions were 0.605 ($p < 0.01$) and 0.477 ($p < 0.01$), respectively. The impacts of attitude and perceived behavioral control on intention were positive and significant at the 1% confidence level, suggesting that the farmers' attitudes and perceived behavioral controls had a significant positive influence on their intentions to reuse agricultural biomass waste. However, the standardized path coefficient of the farmers' subjective norms on their intentions did not reach the significant level on the statistics. Thus, the farmers' subjective norms did not have a significant effect on their intentions to reuse agricultural biomass waste.

3.4. Multiple-group analyses

The existing relevant studies have demonstrated that farmers' decisions are also affected by their individual characteristics, such as gender, age (Echegaray and Hansstein, 2017), educational level (He et al., 2016b), farming experience (Arunrat et al., 2017), part-time job and income level (Mantovani et al., 2017). Thus, multiple-group analyses were performed to identify the differences of the driving factors between different types of farmers on their intentions to reuse agricultural biomass waste. All goodness-of-fit statistics except the RFI value of multiple-group analyses were verified, indicating that the model fit the practical data with a good convergent validity.

The results for multiple-group analyses based on the farmers' gender, age, educational level, farming experience, part-time job and income level, are shown in Table 4. The estimation results indicated that, for the farmers who were female, highly educated, having high income or less experienced in farming, their intentions to reuse agricultural biomass waste were significantly and positively influenced by their subjective norms, compared to their counterparts. On the contrary, for the farmers who were male, lowly educated, having low income or more farming experience, the standardized path coefficients of the subjective norms on their intentions were extremely small and not statistically significant. For all types of farmers, their attitudes and perceived behavioral controls had a significantly positive effect on their intentions. The corresponding standardized path coefficients of attitudes on their intentions were a little larger than those of perceived behavioral controls on their intentions. These results were consistent to those from the entire sample in Table 3.

4. Discussion and conclusions

The aim of this study is two-fold: 1) to examine the impact of farmers' cognitions (attitude, subjective norm and perceived behavioral control) on their intentions to reuse agricultural biomass waste for carbon emission abatement; and 2) to identify the differences of the driving factors between different types of farmers on their reuse intentions through multiple-group analyses with regard to farmers' gender, age, educational level, farming experience, part-time job and income level.

The study leads to two major findings. First, based on the theory of planned behavior, farmers' intentions to reuse agricultural biomass waste are significantly influenced by their attitudes (their positive or negative evaluations of reusing agricultural biomass waste), followed by their perceived behavioral controls (their perceptions about their own capabilities). However, the causal relationship between farmers' subjective norms and intentions is not significant except for some groups (see Tables 3 and 4). This finding is consistent with several previous studies on people's intentions or behaviors regarding waste recycling (Knussen et al., 2004; Tonglet et al., 2004). In addition, Yazdanpanah and Forouzani (2015) and Tan et al. (2017) find subjective norm typically plays a less significant role in explaining individual intention than attitude and perceived behavioral control. According to Maslow's theory (1943) of human motivation, physiological needs at the bottom of the pyramid should be first met before other higher-level needs. Once the fundamental needs are well satisfied, higher-level needs emerge. Since the living standard and educational level of farmers in this survey are generally low, most of them only have fundamental needs (e.g., physiological needs, safety needs) to be met, rather than higher-level needs, such as social needs (e.g., belongingness, affection) and spiritual needs (e.g., self-respect, self-actualization). Thus, the farmers will not intentionally pursue social approval or support, but focus more on psychological

[5] The goodness-of-fit indices of the CFA model are judged according to the conventional rules of thumb of Hair et al. (2010) and Byrne (2010).

Table 3
Results of SEM estimation and hypothesis test.

Path	Unstandardized path coefficient	Standardized path coefficient	S.E.	C.R.	Hypothesis
IN < −AT	0.815***	0.605***	0.119	6.874	H1
IN < −SN	0.025	0.019	0.086	0.289	H2
IN < −PBC	0.571***	0.477***	0.128	4.466	H3

Note: ***, **, *, significant at 1%, 5% and 10%, respectively.

Table 4
Results of multiple-group analyses.

Path	Gender		Age		Educational level	
	Female	Male	Young	Old	Low	High
H1:IN < − AT	0.595***	0.695***	0.512***	0.760***	0.623***	0.691***
H2:IN < − SN	0.285**	−0.061	0.094	0.037	0.032	0.306*
H3:IN < − PBC	0.280**	0.439***	0.419***	0.340***	0.421***	0.259
Path	Farming experience		Part-time job		Income level	
	Less	More	No	Yes	Low	High
H1:IN < −AT	0.530***	0.757***	0.662***	0.570***	0.746***	0.396***
H2:IN < −SN	0.164*	−0.002	0.034	0.070	0.006	0.210*
H3:IN < −PBC	0.428***	0.333**	0.441**	0.388***	0.337***	0.362**

Note: ***, **, *, significant at 1%, 5% and 10%, respectively. The farmers aged 50 or younger were classified as the young or middle-aged group, and those aged over 50 were classified as the old group; the farmers with primary school education or below were classified as the low-educated group, and those with junior high school education or above were classified as the high-educated group; the farmers with farming for 30 years or shorter were classified as the less farming experience group, and those with farming over 30 years were classified as the more farming experience group; the farmers with income at or below 40 000 yuan (equals $6042) a year were classified as the low-income group, and those with income over 40 000 yuan a year were classified as the high-income group.

presupposition (i.e., limited by their own thought inertia) while making decisions. Therefore, the influence of social pressures on the farmers' decisions is relatively weak.

Second, we find that there are differences between different types of farmers (classified by gender, educational level, income level and farming experience) in terms of the significant relationship between subjective norm and intention (see Table 4). For the farmers who are female, highly educated (junior high school education or above), having high income (over 40 000 yuan a year) or less farming experience (30 years or less), their intentions to reuse agricultural biomass waste are also influenced by their subjective norms. In this sense, they are more likely to feel much higher social pressures for reusing agricultural biomass waste and then change their behaviors to show commitment to the values shared within their social culture (Borges and Lansink, 2016). On the contrary, for the farmers who are male, lowly educated, having low income or more farming experience, their intentions are not significantly affected by their subjective norms, as they will pay more attention to their own perceptions and attitudes towards reusing agricultural biomass waste rather than following others' advices.

Specifically, 1) female farmers are easily influenced by the opinions or behaviors of others around them, especially influential people such as village administrators, wealthy farmers or highly educated neighbors in rural society. This finding is supported by Zhang et al. (2013) who find that females' consciousness of independent thinking and judgment is generally not as strong as that of males, and the latter are usually self-determined and not easily influenced by the outside world. 2) Farmers with a high educational level have much greater acceptance of low carbon agriculture and utilization technology of agricultural biomass waste and other emerging environmental protection concepts, which is consistent with the previous study (He et al., 2016b). Also, Zhang (2007) finds that farmers with a low educational level are more likely to be constrained by social standards, as their minds and horizon are restricted by poor knowledge and strong "small farmers' mentality" (i.e. involuntary "selfish behavior"). 3) Farmers with high income are financially capable of adopting the advocated utilization technology of society to gain maximized outcomes. However, farmers with low income may spend more effort to balancing their financial status with basic substance needs and agricultural production in their own families (Mantovani et al., 2017). As a result, less attention will be paid to gain and exchange information with the outside world. 4) Farmers with less farming experience will tend to follow suggestions or opinions from more knowledgeable and experienced farmers (Arunrat et al., 2017), while those with more farming experience are more likely to form conservative or long-term disposal habits of agricultural biomass waste.

For all types of farmers, the results reveal that attitudes have a stronger effect than perceived behavioral controls on the farmers' intentions to reuse agricultural biomass waste in general. On one hand, if farmers have no doubts about the environmental and social value of reusing agricultural biomass waste for carbon emission abatement, or accept concepts of low carbon agriculture, their intentions will go up substantially. On the other hand, if farmers can perceive and assess the ecological or economic benefits of reusing agricultural biomass waste based on their own knowledge, resources, and technologies, they become more confident to participate in a carbon emission abatement program.

These findings provide support for the applicability of the TPB model in predicting farmers' agricultural biomass waste reuse intentions in China. Meanwhile, this study contributes to the existing practice by providing useful insights into the differences of psychological factors on different types of farmers' reuse intentions. Effective approaches should be developed to cultivate farmers' positive attitudes towards these reuse practices to mitigate climate change. For example, the subsidies demonstration zones of energy-saving and emission-reduction projects (e.g., rural biogas project, electricity generation project from straw, cultivation project of straw rotting fungus) can be set up to encourage farmers to reuse agricultural biomass waste. Furthermore, farmers' awareness of the ecological benefits from their own actions must be improved, which will raise their enthusiasm to take initiative in carbon emission abatement programs. We can also target the farmers who are female, highly educated, having high income or less farming experience to raise their social norms consciousness of low carbon agriculture. For instance, village administrators, wealthy farmers and other influential people in villages can be invited to distribute their knowledge of reusing agricultural biomass waste and other constructive behaviors for carbon emission abatement in agriculture. The conclusions of this study also provide an important scientific basis for developing countries and regions to formulate incentive policies in terms of how to motivate farmers to reuse agricultural biomass waste.

5. Limitations and further research

This study enhances the knowledge about the influence of farmers' cognitions (specifically, attitudes, subjective norms, and

perceived behavioral controls) on their intentions to reuse agricultural biomass waste based on the theory of planned behavior. However, there are several limitations worth mentioning. First, this study concerns farmers' intentions to reuse instead of their actual reuse behaviors. According to the study of Armitage and Conner (2001), the theory of planned behavior predicts up to 39% and 27% of the variance in intention and behavior, respectively. Future studies can be conducted to test the TPB model by measuring both farmers' reuse intentions and behaviors at the same time and explore the mediating effect within the model. Second, we only verified the applicability of the classic TPB model for explaining a farmer's intentions to reuse agricultural biomass waste. Actually, the classic TPB model can be extended by adding moral belief or obligation to increase its explanatory power for people's environmental behaviors (Chen, 2016; Tan et al., 2017). Further studies can try to add specific predictors to improve the predictability of the model on farmers' reuse intentions and behaviors, and then assess the extent of the gap between their intentions and behaviors in reusing agricultural biomass waste for carbon emission abatement.

Declaration of conflicting interests

The authors declare no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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